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ABSTRACT

This report is designed to help frame discussion and analysis of data that will emerge from the Third International Mathematics and Science Study (TIMSS), a landmark study of mathematics and science education that investigates the mathematics and science curricula at three academic levels--age 9, age 13, and the last year of high school--in more than 40 countries. The primary source for this report is the first released component of TIMSS, the Survey of Mathematics and Science Opportunities (SMSO). It also draws on related published documents and on informal consultation with TIMSS staff and highlights directions for further inquiry more than findings. The focus of this report is on what TIMSS will be able to contribute to the understanding of mathematics and science education around the world as well as to current efforts to improve student learning, particularly in the United States. Topics covered include information on TIMSS, opportunity to learn, kinds of information collected by TIMSS researchers, challenges and opportunities of cross-national research, information on SMSO, what can be learned from SMSO, intended curriculum, implemented curriculum and instructional practices, and further questions that might be explored by TIMSS. It is concluded that SMSO and TIMSS offer an important opportunity to learn more about international variations in curriculum and instructional practice in mathematics and science, and this data provides a rare opportunity in discourse about mathematics and science education, its analysis, and improvement. (JRH)

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MATHEMATICS AND SCIENCE EDUCATION AROUND THE WORLD

What Can We Learn?

From the Survey of Mathematics and Science Opportunities (SMSO) and the Third International Mathematics and Science Study (TIMSS)

A REPORT OF THE CENTER FOR SCIENCE, MATHEMATICS, AND ENGINEERING EDUCATION
NATIONAL RESEARCH COUNCIL

Mathematics and Science Education Around the World:

What Can We Learn from the Survey of Mathematics and Science Opportunities (SMSO) and the Third International Mathematics and Science Study (TIMSS)?

"SMSO to TIMSS" Writing Committee
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A joint project of:
Mathematical Sciences Education Board
and
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Center for Science, Mathematics, and Engineering Education
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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

The Mathematical Sciences Education Board (MSEB) was established in 1985 by the National Research Council, to "maintain a national capability for assessing the status and quality of mathematics education." Since its inception, the MSEB has been deeply interested in international comparative studies which can illuminate public understanding of the U.S. mathematics education system. The MSEB sponsored a convocation on "International Comparisons of Mathematics Education: Policy Implications for the United States," in conjunction with the Second International Mathematics Study, in 1987. It has hosted several presentations on the recently completed Third International Mathematics and Science Study (TIMSS) at its Board meetings in the past few years.

In 1995, when the NRC established the Center for Science, Mathematics, and Engineering Education, the MSEB was joined by the Committee on Science Education (COSE K-12). In response to a request from the National Science Foundation, and with its support, MSEB and COSE K-12 have joined to produce this short report, in preparation for the impending release of the TIMSS data. It is further accompanied by a brochure, intended for broad public dissemination.

This report is designed to help frame discussion and analysis of data that will emerge from TIMSS, a landmark study of mathematics and science education that investigates the mathematics and science curricula at three academic levels (age 9, age 13, and the last year of high school), in more than forty countries. Compared to its predecessors, and to other international comparative studies, TIMSS is noteworthy both in the number of variables documented and in the sophistication of the instruments used.

The primary source for this report is the first released component of TIMSS, the Survey of Mathematics and Science Opportunities (SMSO); it draws also on related published documents, and on informal consultation with TIMSS staff. Direct access to the TIMSS data was restricted. Accordingly, this report highlights directions for further inquiry more than findings. It should not be construed as a review of the SMSO design and methodology, although we expect that such review and critique will be undertaken by the field.

SMSO, a study of six of the TIMSS countries, was intended to develop and pilot the innovative survey instruments and international comparison frameworks employed by TIMSS. These frameworks distinguish three expressions of curriculum: the *intended curriculum* is examined through textbooks and lists of goals and objectives formulated at national, state, or local levels; the *implemented curriculum* or the patterns of instructional practice, is studied using questionnaires and, on a smaller scale, classroom observation; the *attained curriculum* is measured through student achievement data. The development and piloting process undertaken by SMSO also revealed some fundamental, and sometimes surprising, subtleties that emerge in making international comparisons.

The value to an individual country of international comparative studies is not so much to furnish a ranking, but rather to provide a broad knowledge base with which to understand and improve its own condition. To serve this end, international educational studies must provide, in addition to rankings of achievement, contextual data that permit analysis and interpretation of the observed outcomes. Imagine for example, international statistics on mortality rates, or the epidemiological

patterns of certain diseases. Such data would be of limited use if not accompanied by country-specific information about diet, lifestyles, physical environment, social institutions, and so on.

What is most significant about TIMSS is the degree to which it will furnish profiles of curricular and instructional practices, thereby providing the context for interpreting its achievement data. In place of the premature and inappropriate conclusions sometimes drawn from past achievement data, TIMSS presents an unprecedented opportunity to initiate informed analysis and interpretation of the culturally diverse conditions and practices that have produced its achievement results. *A primary purpose of this report is to help promote this stance for the reception of the TIMSS data by the various communities concerned with educational improvement in the U.S. TIMSS and SMSO do not furnish conclusions; rather they invite and enable fruitful inquiry.* This report indicates some such directions of inquiry that emerge already from SMSO.

There are moments when the conditions that favor responsible scholarship - thorough and unrushed analysis and synthesis of existing data and research - brush against the expediencies of engagement with real events in real time. The production of this report represents such an occasion. The precipitating event is the impending release of the TIMSS data, and the attendant potential for widespread misinterpretation. Enthusiasm for international comparisons creates a pressure for fast reporting of summary data, without crucial analyses. Efforts to improve mathematics and science education in the U.S. are now intense, and their aims and effects are widely debated. The TIMSS data have the potential to inform these debates and to contribute to these efforts at improvement. By the same token, inappropriate uses of the data have the potential to impede the progress of educational improvement. The public, eager to know how the United States compares with other countries, is prone to draw quick conclusions without adequate analysis or discussion. This danger is what gives urgency to the central message of this letter report. If TIMSS is to provide the kinds of resources for educational improvement of which it is capable, careful analyses of the relations among critical variables will be crucial. We seek in this document to orient others to this important study, and to begin the process of questioning and analysis that can most effectively contribute to educational improvement.

In order for this report to most effectively serve its public information purpose, it had to be available in close proximity to the release of the TIMSS data. This required that it be executed with extraordinary dispatch. It is a tribute to the writing group assembled that this was accomplished. Joan Ferrini-Mundy deftly organized and conceptualized this effort; she further assured, under conditions of limited access to source materials, the scholarly rigor of the report. She was greatly aided by generous and dedicated staff support from Ramona Irvin. It is unlikely that this would have reached successful conclusion in timely fashion without the extraordinary intellectual leadership and writing skills of Deborah Ball, to whom we all are deeply indebted.

Hyman Bass, Chair
Mathematical Sciences
Education Board

Jane Butler Kahle, Chair
Committee on Science
Education K-12

**Mathematics and Science Education Around the World:
What Can We Learn from the Survey of Mathematics and Science Opportunities (SMSO)
and the Third International Mathematics and Science Study (TIMSS)?**

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Overview

Amid current efforts to improve mathematics and science education in the United States, people often ask how these subjects are organized and taught in other countries. They hear repeatedly that other countries produce higher student achievement. Teachers and parents wonder about the answers to questions like these: Why do the children in Asian cultures seem to be so good at science and mathematics? How are biology and physics taught in the French curriculum? What are textbooks like elsewhere, and how much latitude do teachers have in the way they follow the texts? Do all students receive the same education, or are they grouped by ability or perceived educational promise? If students are grouped, how early is this done? What are tests like, and what are the consequences for students? Are other countries engaged in Standards-like reforms? Does anything like "standards" play a role in other countries?

At times, international comparisons are framed not as questions but as assertions, such as "The Asians cover many more topics"; "The Japanese are in school longer"; "The French require more homework"; "High levels of instant recall and speed in calculations are required of Chinese students." These assertions reflect widely shared beliefs about education in other countries. Although these claims are quite common, their factual bases vary. They indicate the high level of attention to mathematics and science education around the world.

Naturally, interest is greatest about countries whose students seemingly outperform U.S. students. Sometimes this intense interest stems from a desire to identify those practices that are associated with student achievement, characterized by the question, "What are other countries doing that works?" Sometimes the interest is rooted in a defensiveness, expressed as "They only score higher because they exclude so many of their students by high school, while we educate all our students" or as "The pressure on their students is excruciating."

Questions such as these reflect more than a casual interest in other countries' educational practices. They grow out of an interest in identifying ways to improve mathematics and science education in the United States.

In this report, we introduce the Third International Mathematics and Science Study (TIMSS),[1] a major international investigation of curriculum, instruction, and learning in mathematics and science, which will provide resources for addressing these and other important questions. We draw on a pilot

[1]TIMSS is a collaborative research project sponsored by the International Association for the Evaluation of Educational Achievement (IEA). The IEA will release a series of international TIMSS reports beginning in the fall of 1996. Several U.S. TIMSS reports, including detailed reports on findings and methodology, also will be released beginning at this time. Dr. Albert Beaton, Boston College, is the TIMSS International Study Director. Dr. William Schmidt, Michigan State University, is the U.S. National Research Coordinator.

Recommended citation: National Research Council. (1996). *Mathematics and science education around the world: What can we learn from the Survey of Mathematics and Science Opportunities (SMSO) and the Third International Mathematics and Science Study (TIMSS)?* Washington, DC: National Academy Press.

project related to this study, the Survey of Mathematics and Science Opportunities (SMSO)[2,3]. SMSO describes the development and piloting of the TIMSS instruments and methodology and reports preliminary findings.

The focus of this short report is on what TIMSS will be able to contribute to understandings of mathematics and science education around the world as well as to current efforts to improve student learning, particularly in the United States. The report centers on three sets of questions:

- *What is the Third International Mathematics and Science Study (TIMSS)?* How is opportunity to learn viewed in TIMSS? What kinds of information have the researchers collected? What are some of the challenges and opportunities of cross-national work?

- *What is the Survey of Mathematics and Science Opportunities (SMSO)?* What can be learned from it? What does SMSO say about intended curriculum? What does SMSO say about the implemented curriculum and instructional practices?

- *What questions might be explored with TIMSS?* What do the preliminary issues in SMSO suggest about questions that should be pursued in the TIMSS data? What issues raised by this first study are important to bear in mind in interpreting TIMSS findings? What are the implications for secondary analysis?

The release of results from TIMSS, beginning in 1996-1997, will attract significant interest and attention. A study such as this is a complicated undertaking. Factors that may vary dramatically across countries include educational objectives and examinations. There are important differences in how educational objectives and examinations are determined, how they influence teaching and learning, and how they are viewed. The TIMSS data, which focus not only on student achievement but also on educational systems and practices, will make it possible to ask questions about and analyze factors that combine to influence educational outcomes.

Due to substantial developments in methods of international comparison as well as the ambitious scope of the TIMSS study, the analyses possible with the TIMSS data set will be unprecedented. The study is also an object of concern for some observers. Issues of quality control in sampling, translation of instruments, and collection and management of data are sometimes problematic in international studies.[4] The task of this report is not to assess TIMSS or SMSO. The report neither

[2]The SMSO project began in 1991 as a collaborative effort to understand the key elements of teaching and learning in mathematics and science classrooms in six countries. SMSO was intended to develop theoretical models and methodological tools to inform the design of TIMSS. SMSO is described in Schmidt, et al. (1996). *Characterizing pedagogical flow: An investigation of mathematics and science teaching in six countries.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

[3]TIMSS and SMSO are funded by the National Science Foundation, the National Center for Education Statistics, the Canadian Ministry of Human Resources Development, and participating countries.

[4]Board on International Comparative Studies in Education. (1993). *A collaborative agenda for improving international comparative studies in education.* Washington, DC: National Research Council.

endorses nor critiques this research. As these data about curriculum, teaching, and student achievement emerge, the methods of the work will be criticized, questioned, and lauded. Written before the release of the TIMSS data and hence too early for a careful review of the study or its products, this report aims instead to inform the reader about TIMSS and to foreshadow the kinds of questions, information, and interpretations that may follow. The scope of the study is large; the challenge to make sense of the information great. The utility, reliability, and validity of the information and interpretations that TIMSS will produce remains to be seen.

This report is intended to set the stage for discussions and constructive utilization of an undeniably extensive data set about mathematics and science education. We do this in two ways. First, we present a summary of the TIMSS research framework and methods, then we highlight preliminary findings from SMSO about curriculum and teaching and point to questions raised by these findings.

What Is the Third International Mathematics and Science Study (TIMSS)?

Beginning in 1996-97, data from the Third International Mathematics and Science Study (TIMSS), will be released. This ambitious cross-national study measures student achievement in 44 countries (see Appendix 1). In addition, extensive data have been gathered about conditions of schooling, curriculum, and instructional practice. The ultimate potential of TIMSS is to be able to place each country's student achievement data within a sufficiently complex portrait of that country's educational system to enable identification, examination, and analysis of important relations among factors. Such analyses are essential to informed judgments about ways to improve education.

TIMSS will report on the mathematics and science achievement of students enrolled in the two adjacent grades that contain the largest proportion of 9-year-olds, the two adjacent grades that contain the largest proportion of 13-year-olds, and students in their final year of secondary education. All countries participated in testing 13-year-olds; testing at other grade levels was optional. The achievement data were gathered primarily in the 1994-95 academic year. See Appendix 4 for data release plans.

How Is Opportunity to Learn Viewed in TIMSS?

The TIMSS design reflects the importance of analyzing relationships between opportunities to learn and educational outcomes. The three basic elements of TIMSS are the *intended curriculum* (the educational system's aims and goals); the *implemented curriculum* (the actual strategies, practices, and activities found in classrooms); and the *attained curriculum* (student learning). Consistent with this basic structure, the TIMSS perspective on educational experience includes school variables and processes and a view of student learning influenced by psychological and sociological perspectives. The TIMSS conceptual model (Appendix 2) provided a theoretical foundation for collecting data and an initial approach to examining relationships among findings. Four questions are at the heart of the design. One central question, "What are students expected to learn?", corresponds to the *intended curriculum*. A second question adds a focus on teachers -- "Who delivers the instruction?" The third

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question represents the *implemented curriculum*, "How is instruction organized?", while the fourth, "What have students learned?", corresponds to the *attained curriculum*.

What Kinds of Information Have the TIMSS Researchers Collected?

In order to make sense of the TIMSS data and analyses, it is important to know how the researchers conceptualized -- and then investigated -- several elements of educational systems. Analyses that explore connections among these elements are likely to be most productive in enabling valid interpretations and conclusions. For instance, information gathered on the content and use of textbooks provides a view of the curriculum that is complementary to data gathered on curriculum frameworks and tests. Knowing what is in textbooks and how widely they are used or whether and how they are even required offers insight into the potential influence of curriculum material on what students have opportunities to learn. Yet such information does not necessarily provide insight into the curriculum that students encounter in the classroom. Teachers' decisions about the organization and presentation of material also shape the curriculum. And knowing what students are taught still would not tell us what any particular student experiences, as mediated by his or her own interpretations. All these differences in meaning of curriculum highlight the interface between *intended* and *implemented* curriculum.

There are many different ways to interpret what is meant by curriculum. No one is somehow "right"; instead, the interpretation depends on the questions one is trying to answer about curriculum. In examining data, it is important to understand how curriculum is being defined. What did the TIMSS mean by, and how did researchers gather data on, documents and texts -- the intended curriculum? On instructional practices -- the implemented curriculum? On student learning -- the attained curriculum? Understanding their meanings is crucial to interpreting the TIMSS findings.

> **The *intended curriculum*:** TIMSS focused on three elements of the *intended curriculum*. First, researchers gathered and examined a variety of documents from each country that offered clues to the curriculum, as it was publicly defined.[5] In many countries, the intended curriculum is articulated nationally, through framework documents. In some countries, such as the United States and Switzerland, the curriculum is for the most part specified at the state, district, or canton[6] -- not the national -- level. In all cases, the researchers read and analyzed curriculum guides and lists of objectives.
>
> Textbooks comprised a second element of the curriculum examined by TIMSS researchers. Researchers assembled a collection of mathematics and science textbooks from each country. Approximately 1,600 teachers' guides and textbooks were analyzed across participating countries. Wherever possible, the materials were selected to represent those used by a majority of a given nation's students.

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[5]The publication dates of these materials ranged from 1976 to 1994. The set of U.S. materials was dated between 1978 and 1994.

[6]A canton in Switzerland corresponds roughly to a state in the U.S.

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TIMSS researchers developed analytic frameworks[7] for examining the intended curriculum according to the aspects of content, performance expectations, and perspectives. In Appendix 3, categories within each of these three aspects are listed. Separate frameworks were developed for mathematics and science. Researchers coded each sample of material according to its categorization in each of the three aspects of the framework.

The TIMSS analysis of curriculum documents and textbooks will offer a multidimensional portrait of the *intended curriculum* in participating countries.

The *implemented curriculum*: The *implemented curriculum* was studied in several different ways in TIMSS. Questionnaires were used to survey teachers about their instructional practices. Teachers were asked how they use textbooks and technology, the activities they employ, what they cover during the year, what they believe about students and about learning, and what they think in many other areas of their teaching.[8] In addition, they were asked about staffing and other administrative matters.

In another major component of TIMSS, researchers videotaped a sample of eighth grade mathematics lessons in Germany, Japan, and the U. S. and conducted close analyses of the different pedagogical styles and the implemented curricula.[9] Finally, detailed case studies, examining issues of education context more generally, were conducted in the same three countries.[10] As part of the case study project, school administrators were interviewed for school-level information about the cultural and contextual factors that influence students' academic achievement.

The *attained curriculum*: More than a half million students were assessed in TIMSS. Students in three age groups were studied: 9-year-olds (Population 1), 13-year-olds (Population 2), and a broad range of students in the final year of secondary school (Population 3). The assessment measures included multiple-choice and free-response items. With a random subsample of students in Populations 1 and 2, performance assessment tasks also were administered.[11] Many different mathematics and science topics were included across the assessment instruments, and some tasks involved understandings of more than one topic.[12]

7Robitaille, D., Schmidt, W., Raizen, S., McKnight, C., Britton, E., Nicol, C. (1993). *Curriculum frameworks for mathematics and science.* (TIMSS Monograph No. 1). Vancouver: Pacific Educational Press.
8 To be reported in *U.S. Survey Report, International Questionnaire Results.*
9 Stigler, et al. (in press, 1996). *TIMSS classroom videotape studies: Preliminary findings and methodology.* (National Center for Education Statistics of the U.S. Department of Education). Washington, DC: Government Printing Office.
10To be reported in Stevenson, H. *Findings from ethnographic case studies in Germany, Japan, and the U.S.*
11Westat, Inc., *U.S. TIMSS Bulletin. No. 1.* [Brochure]. Rockville, MD.
12Garden, R.A. (1996). Development of the TIMSS achievement items. In D.F. Robitaille & R.A. Garden, (Eds.), *Research questions & study design.* (TIMSS Monograph No. 2). Vancouver: Pacific International Press., and Schmidt, W.H. & McKnight, C.C. (1995). Surveying educational opportunity in mathematics and science: An international perspective. *Educational evaluation and policy analysis, 17*(3), 337-353.

What Are Some of the Challenges and Opportunities of Cross-National Research?

International studies are sometimes interpreted as a competition among the participating countries, a "horse race" in which countries seek to rank high on some finish list. However, such comparisons are not the most productive way to use and learn from complex multinational studies. Studying curriculum, teaching, and learning is a complicated endeavor. When such research is conducted in multiple educational contexts, a wider set of interesting contrasts and possible relationships exists. It becomes possible to delve deeply into how curriculum and teaching interact to affect students' experiences and various outcomes of schooling. Moreover, the wider variation in educational practice also offers views of what is possible in curriculum and teaching. Such images can be a crucial resource for the design of educational improvement.[13] Some issues that can be examined with cross-national studies include the following:

- *The identification of factors that affect learning:* There is considerable variation in educational practices across countries. In international studies, variables such as class size, age of school entry, who attends what schools, and the role and nature of assessment can be examined more comprehensively and described within different countries' contexts.

- *The identification and examination of pedagogical approaches:* Just as cultural and political parameters that may affect learning vary across countries, so, too, do teaching practices. Different approaches to teaching can be identified, described, and analyzed for their underlying assumptions about learning, children, and subject matter as well as about the purposes of schooling. In international studies, a wide array of alternatives is offered, which can contribute to expanding our images of teaching. The challenges of educational innovation also can be examined in looking across the various efforts in different countries.

- *Analysis of how curriculum and pedagogy are embedded in broader educational and social contexts:* Across countries there not only are differences in elements such as structures of schooling, curriculum, and pedagogical approach, but there are salient cultural, social, and political differences as well. International studies offer opportunities to probe factors that seem to shape the interplay of content, pedagogy, and learning. Where systems produce consistently high or low student achievement, comparative studies make it possible to examine factors that may influence such outcomes.

Although the naturally occurring variation among countries makes international studies rich opportunities for learning, TIMSS also has the potential to provide a current portrait of practice and achievement within each country. TIMSS will give Americans unprecedented access to recent, systematically gathered information about curriculum, teaching, and learning in the United States.

[13]Board on International Comparative Studies in Education. (1993). *A collaborative agenda for improving international comparative studies in education*. Washington, DC: National Research Council.

This information will be an important resource in efforts to improve mathematics and science education because it will enable better understanding of our own educational system.

International studies are sometimes viewed with suspicion.[14,15] Skeptics argue that cultural and social factors vary so much across countries as to make comparisons impossible. They point also to the difficulties of creating instruments and conceptual categories that are usable across cultural contexts. In SMSO, substantial time and intellectual resources were invested in instrument development and research design to deal with these serious challenges. TIMSS researchers wanted to avoid the assumption that the critical educational elements were identical across contexts or that they meant the same thing. But they also sought to avoid tailoring the methods of research to each country on an individual basis because such tailoring would make comparative analyses virtually impossible.

What Is the Survey of Mathematics and Science Opportunities (SMSO)?

Gathering cross-national data of this complexity and scale called for the development and piloting of innovative survey instruments. The Survey of Mathematics and Science Opportunities (SMSO) was originally designed to develop instruments and methods of analysis that would be suitable for the complexity of the TIMSS research. In SMSO, an international collaborative research team undertook the task of conducting close observations of classrooms in six of the TIMSS countries: France, Japan, Norway, Spain, Switzerland, and the United States.[16] The central questions of SMSO were, "*What does a typical mathematics lesson look like?*" and "*What does a typical science lesson look like?*" The goal was to understand enough about teaching and curriculum within each country that the design of survey instruments for TIMSS would allow for comparisons and also be sufficiently sensitive to cultural differences. This pilot work was done to increase the potential of providing valid information for interpreting variations in student achievement. SMSO researchers observed classroom lessons in their own countries, read one another's written classroom observations, and discussed meanings of practices, terms, assumptions, and norms. They also developed, piloted, and revised survey instruments based on teachers' interpretations and responses. In studying the implemented curriculum -- teaching practice -- researchers observed 127 classrooms across six countries and three levels. These classrooms were never intended to constitute a probability sample of classrooms in the countries but, rather, to provide sufficient variation overall to ensure good instrument development for TIMSS. This report draws primarily on the results of SMSO as a means to introduce and set the stage for discussion of TIMSS.

A fundamental premise for the SMSO effort was that the variation in learning conditions across countries would be critical to development of TIMSS survey items and to sensible interpretation of the TIMSS student achievement data. The meaning of this premise became more complicated as the

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14Berliner, D. & Biddle, B. (1995). *The manufactured crisis: Myths, fraud, and the attack on America's public schools.* Reading, MA: Addison Wesley.
15Bracey, G.W. (1996, January-February). International comparisons and the condition of American education. *Educational Researcher, 25*(1), 5-11.
16These countries were selected to provide variation of the kinds expected across the TIMSS participating nations, so that the instruments would be designed to work across varied settings.

international team of SMSO researchers discovered differences in taken-for-granted operational definitions for common educational expressions. For example, "seatwork" is a common part of U.S. classes, especially in mathematics, and in the U.S., the researchers found, the term was used to refer to independent practice or review work. In some other countries, although students did independent work at their seats, such work was intermittent and was woven into an ongoing whole group lesson. Researchers learned that periods of independent student class work and how this work fit into the larger class agenda varied enough to make the term "seatwork" as understood in the U.S. almost meaningless in the international context. Other examples of fundamental differences included the concept of a "lesson"-- in terms of length, structure, and frequency -- as well as the length of time that teachers work with the same group of students. In some countries, teachers stay with the same students for as many as six years. This may well affect what teachers know about their students. In yet another example, in Switzerland, primary schools do not have principals - a fact that the researchers learned during a data collection planning meeting. The team realized that this fact might represent an important element of Swiss educational practice and that, indeed, the very concept of a "school" might be different across countries, with the relevant organizational unit different in different contexts.

These and other discoveries were important to the ultimate design of survey instruments for the larger TIMSS study. SMSO work proceeded through a series of iterations. Qualitative observations and interviews were discussed at length, and the insights reached by the team in turn shaped revisions of quantitative survey instruments. The SMSO research team found the process challenging and worthwhile, well beyond its contributions to instrument development for the larger study. Titling an entire section of their report, "Value of International Discourse," the researchers explained that the "discourse process . . . led to insights not possible with a more traditional model."[17] "Confusion and surprise" emerged often, and through discussions, research team participants clarified their ideas. They found that they had learned a great deal about educational practice and comparison in their efforts to reach shared understandings about instrument items and ideas. The group noted the subtleties of difference in practice underlying surface similarities of language. The SMSO researchers decided that the SMSO methodology and the results would be of interest and importance in their own right. The SMSO report will be released with the TIMSS curriculum studies.[18]

[17]Schmidt, W.H., et al. (in press). *Characterizing pedagogical flow: An investigation of mathematics and science teaching in six countries*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

[18]Schmidt, W.H., McKnight, C.C., Valverde, G.A., Hohang, R.T., & Wiley, D.E. (in press). *Many visions, many aims: A cross-national investigation of curricular intentions in school mathematics*. Dordrecht, The Netherlands: Kluwer Academic Publishers, and Schmidt, W.H., Raizen, S.A., Britton, E.D., Bianchi, L.J., & Wolfe, R.G. (in press, 1996). *Many visions, many aims: A cross-national investigation of curricular intentions in school science*. Dordrecht, The Netherlands: Kluwer Academy Publishers.

What Can Be Learned from the Survey of Mathematics and Science Opportunities (SMSO)?

SMSO researchers have helped develop new research tools, hypotheses, and approaches. These include methodologies for comparative studies of curriculum and context-sensitive methods of developing survey instruments and observation guides. In addition, SMSO offers ideas about international differences in curriculum and some preliminary observations about how instruction may vary across countries. These ideas are valuable for what they show about the complexities of making cross-national comparisons. At the same time, the SMSO preliminary findings point to the value of probing those comparisons carefully and illustrate what can be learned from the similarities and differences. SMSO was not intended to provide conclusive analyses about international differences and should not be read in that way.

This section is divided in two parts, one focused on insights that SMSO reports from investigating the six countries' *intended curriculum* in mathematics and science and the second on what emerged from their observations of *instructional practices*. Our purpose here is to highlight the types of issues that can be pursued with international comparisons. References to specific countries are provided to illustrate broad comparative statements, not to make generalizations about those countries.

What Does SMSO Say about Intended Curriculum?

Discussion of intended curriculum in SMSO is based on data gathered about curriculum guides and texts using the TIMSS curriculum frameworks,[19] as well as on information from the countries about the structures and authority for curriculum decision-making and guidance. We briefly highlight three provisional findings reported by SMSO: one about the mathematics and science content included in the intended curriculum across the six countries, one about differences between the mathematics and science curriculum across the six countries, and one about how the intended curriculum is determined in these different countries.

- *What does the curriculum analysis reveal about the content of mathematics and science curriculum frameworks and textbooks across the six SMSO countries?*

There are many ways in which one might expect curricula in different countries to vary. Prominent dimensions in curriculum include the number of topics to be covered each year, topic sequence, topic development, and depth and breadth of the curriculum.

When they considered the number of topics to be covered, SMSO researchers found that some countries, such as Japan, and Spain, aim for a smaller number of mathematics topics each year and that, in contrast, Norway, France, and the United States cover many more mathematics topics per

[19]Robitaille, D., Schmidt, W., Raizen, S., McKnight, C., Britton, E., Nicol, C. (1993). *Curriculum frameworks for mathematics and science.* (TIMSS Monograph No. 1). Vancouver: Pacific Educational Press.

year. Science textbooks examined in France, Japan, and Norway appear to include more detail on fewer topics than do the textbooks examined in the other countries.

SMSO found that, in the intended curricula of some countries, particular topics are emphasized and developed with concentration and focus and then are sustained over several years. In contrast, topics appear in the curriculum in other countries over and over but never seem to receive a sustained emphasis. For example, the materials examined from Japan emphasized "equations and formulas" in virtually every grade, while materials from Norway and Spain did not emphasize this topic in any grade. In France, the analysis indicated that "chemical properties of matter" is introduced to students at age 13 and emphasized at ages 15, 16, and 17, while in Norway, the same topic is introduced to students at age 10 and addressed each year thereafter but never emphasized. In science, Switzerland's pattern generally showed relatively late introduction and focus emphasis for most topics.

The SMSO study also found differences in when a topic first appears in the intended curriculum, as well as when it is dropped. For example, the Japanese curriculum introduces some algebra topics to students as early as age 8, while in Spain those topics are not introduced to students until age 12. Science topics such as "reproduction of organisms" and "earth building and breaking processes" are introduced in the U.S. several years earlier in the curriculum than they are in Japan. In other science topic areas, such as "organs and tissues," coverage in the typical American text ends the year after it is first introduced in Swiss texts. In the U.S., there also is a tendency to address a given topic repeatedly over a period of several grades. In Japan, it is more common for a topic to be dealt with entirely within a grade or two. Understanding these large variations in many dimensions of the intended curriculum is critical to understanding differences in educational practice and achievement across countries.

Variations also are found in the expectations of and demands on students in the intended curriculum. Japanese science textbooks for 13-year-olds are characterized in SMSO as emphasizing "understanding complex and thematic information" more than "simple information." French and Spanish textbooks for this age group exhibit a similar emphasis but to a lesser extent. Differences in emphasis are evident also in mathematics textbooks for this age group. For example, texts in Switzerland and Norway devote more than 50% of their space to "whole number operations." "Properties and meanings of whole numbers" (a more complex topic) occupies 20% of the space in French texts as compared to 2% of the space in Swiss texts and 8% of the space in Norwegian texts. These differences in emphasis and coverage between simple and complex topics suggest substantial differences in performance expectations across the six countries. Even for a topic such as whole number operations for 9-year-olds, the curricula of different countries call for different levels of complexity, which is likely to produce differences student performance.

• *In looking cross-nationally, are there important differences between the mathematics curriculum and the science curriculum?*

As they examined the intended curriculum across countries, SMSO researchers found that the mathematics curriculum and the science curriculum have different characteristics. For example, science curriculum frameworks and textbooks in the six countries were found to contain many more topics than the curriculum frameworks and texts for mathematics. In their report, researchers noted that this is true at both the 9-year-old and 13-year-old levels. A second difference is evident in the volume of content to be taught in mathematics and science. In SMSO countries, although the number of mathematics topics to be taught increases for 13-year-olds, the increase is more dramatic in science. A third difference is that there are more similarities in the mathematics curriculum across countries than in the science curriculum. Clearly, there are important questions to be asked about the differences in the ways that science and mathematics are viewed and taught in different countries. These differences also may have implications for student performance differences in mathematics and science.

• *How is the intended curriculum specified in each country?*

Another salient difference across countries lies in the ways in which the intended curriculum is determined. Decisions about what should be taught and with what priority are made in very different ways across countries. Communication about these different priorities, and the extent to which teachers are expected to follow centralized curriculum guidelines, also vary considerably. The degree of alignment of textbooks with centralized curriculum goals also varies. These issues are not about the actual curriculum encountered in classrooms by students but about how the aims and means of the intended curriculum are articulated.

Of the six SMSO countries, the U.S. has the least centralized control of curriculum. In France, Japan, Norway, and Spain, national curriculum frameworks are developed under the control of centralized government agencies. These frameworks specify curricular goals to be implemented by regions and schools. There is no comparable national curriculum framework for Switzerland or the U.S. In Switzerland, recommended curriculum frameworks do exist within each canton, and in the U.S., most states and many local districts do have curriculum frameworks. However, in the U.S., there is no single pattern of curriculum specification.[20]

Considerable variation also exists in the ways in which textbooks are produced and selected. In virtually all SMSO countries, textbooks are produced by commercial publishers, not by government agencies. In four of the six countries, textbooks must adhere to national guidelines.[21] Selection of

[20]Although there are national standards in mathematics and science in the U.S., these standards, produced by professional organizations, are voluntary.

[21]In the United States, the textbook industry is largely market-driven, but in states where textbooks are approved for a state adoption list from which districts may choose, there exist both formal and informal scope and sequence requirements as well as informal pressure on publishers to meet state curricular guidelines.

textbooks varies across the countries: in some cases, it is the responsibility of individual teachers, while in others, it is the responsibility of schools, school districts, or states. In Norway, textbooks are selected by the national government.

What Does SMSO Say about the Implemented Curriculum and Instructional Practices?

Through observations of 127 classrooms, SMSO researchers also investigated the implemented curriculum -- how content is actually taught -- in the six countries. To draw conclusions about national trends in instructional practice from SMSO classroom data would be unwarranted. However, the differences that emerged are interesting and raise useful questions about the connections of instructional practice to the cultures in which it is embedded. Such questions might help guide examination of the TIMSS achievement data as it is released over the next several months.

One of the most dramatic messages from SMSO is the extraordinary diversity of educational systems and practices and of conceptionalizations of fundamental elements of the educational process. Although the teaching of mathematics and science content is held by some professionals to transcend cultural boundaries, the teaching of mathematics and science appears to be strongly influenced by and reflective of its cultural setting. For example, SMSO researchers not from the U.S. were unfamiliar with the common American practice of having students exchange and check one another's homework papers. The size of classes, the role of teachers, the kinds of academic tasks assigned to students-- these "basics" all seemed deeply embedded in culture as researchers examined teaching in one another's countries.

In order to develop instruments sensitive enough to study teaching across cultural contexts, SMSO researchers devised a framework to guide examination of a few lessons in each country. The framework elements were content complexity and representation, content presentation, and classroom discourse. For content *complexity* and representation, the researchers focused on how content was modeled and represented by teachers. Content *presentation* refers to the strategies used to engage students in the content. *Discourse* was the term used to refer to how students and teachers interacted with one another about content.

Practices in one country often were unfamiliar to those from other countries. However, the SMSO team found that simply focusing on specific differences in practice did not seem to capture the larger, recurrent patterns in pedagogical style and classroom approach that seemed to characterize all the observations within a country. The SMSO report provides illustrations of these sorts of recurrent patterns in both mathematics and science.

What follows are some prominent recurrent features of these patterns, which the researchers noted in the lessons they observed in each country. The anecdotes are based on a few observations and cannot be taken to describe the characteristic practices of any of the six countries. The points raised below are meant therefore to illustrate only the notion that styles and patterns of teaching science and mathematics may be culturally rooted. The larger TIMSS data set will provide opportunities to probe the durability and consistency of this notion.

In the science and mathematics lessons they observed in France, SMSO researchers reported a consistent tendency for the teachers to make formal presentations of complex subject matter. They saw teachers emphasizing formal definitions, laws, and principles and observed students engaged in theoretical reasoning and problem solving. Many of the lessons observed in Spain shared these features. In addition, the small set of Spanish teachers observed seemed to seek to link theoretical principles to practical everyday applications. Textbooks also seemed more central in the Spanish lessons observed in SMSO. A great deal of emphasis also seemed to be placed in Spain on use of homework.

In contrast, the set of mathematics and science lessons in Norway seemed more often to center on helping students develop factual knowledge. The content did not seem as complex or as formal from a disciplinary perspective as what was evident in the French lessons observed. In the judgment of the SMSO research team, the Norwegian teachers sought to engage students in learning activities in both individual and small group work in ways that seemed more child-centered than what was observed in the other countries. Compared to the French and Spanish teachers observed, the Norwegian teachers also spent less time lecturing. It should be noted that observers saw little classroom discussion in these lessons.

The Japanese lessons were quite different from those in France, Norway, and Spain. Observers from SMSO noted an active engagement with the content by both teachers and students. They cited notable emphasis on multiple representations and methods, as well as a considerable amount of complex, content-focused discussion. Some of the discussion in the Japanese lessons seemed to be guided quite strongly by the teacher and focused on eliciting complex ideas rather than on facts or simple understanding.

The Swiss lessons were similar to those in Norway and emphasized student responsibility for learning through teacher-prepared demonstrations and activities. Lessons tended to be structured around a single subject matter idea and covered a small amount of content. Textbooks seemed to play a smaller role than in some other countries observed.

In lessons observed in the U. S., teachers often seemed to be the central figures in the classroom. Frequently, they functioned as transmitters of information. In their report, researchers note that the teachers appeared to be more involved with subject matter content than the students were, although, in some lessons, little actual topic content was observed. The lessons observed tended to be organized, structured, and directed by the teacher, and definitions and vocabulary were emphasized.

The SMSO study of instructional practice raises the important issue of the extent to which mathematics teaching and science teaching are embedded in culture. Although the lessons that the researchers observed across countries shared characteristics, and lessons within countries showed variation, SMSO researchers were able to identify what they believe to be pervasive and recurrent patterns by country. In the report, they employ the term *characteristic pedagogical flow* (CPF) as a way to capture the notion of a cluster of culturally embedded classroom relations, practices, and

patterns. They hypothesize that instructional practice is composed of critical elements of content and discourse and that these cluster in patterns that are characteristic of the culture. They further hypothesize that inter-country variations may well be greater than intra-country variations. These hypotheses merit continued scrutiny and investigation. It will be important to probe the extent to which they seem valid, to attempt to characterize patterns in specific countries, and to consider implications for improving practice.

What Questions Might Be Explored with TIMSS?

The work of SMSO can serve to foreshadow the types of issues that will emerge in TIMSS. The observed patterns of curriculum and instructional practice across the six SMSO countries raise important questions to be explored in depth with the larger TIMSS data sets. This final section poses several such questions.

- ***How much are the differences in mathematics and science curriculum and teaching due to culture and nation and how much are they really just related to individual teacher and student differences?***

  A cross-national study such as TIMSS or the related SMSO raises many questions about the social, political, economic, and cultural factors that play a role in shaping teaching, learning, curriculum, and schooling in a country. How does culture shape the practice of teaching, the nature and purposes of schooling, societal expectations of and support for education, and the experiences of different students? Questions such as these are crucial to interpreting the student achievement data and to understanding factors that may influence students' opportunities to learn, as well as what they actually do learn. Because one use of the TIMSS analysis might be to identify practices that seem to support worthwhile student learning, it will be critical to continue to understand the multiplicity of factors that combine to produce "practice", both through TIMSS and other research. Moreover, acknowledging the extent to which practices are embedded in culture is crucial to understanding what might be involved in transporting educational practices and ideas internationally.

- ***What is meant by a "national curriculum" and what is its role?***

  We see from SMSO that some countries specify aspects of the intended curriculum at the national level. It will be useful to know which of the TIMSS participating nations have some form of nationally specified curriculum in mathematics and science and to examine closely various versions of "national curriculum." In what forms are these specified; e.g., curriculum outlines, textbooks, testing? Who has the authority for determining and articulating national goals? How specific are the goals? Do some national curricula specify instructional practice as well as content? How congruent are textbooks and other instructional materials to the goals specified? To what degree are teachers required to adhere to these goals and in what ways are they enabled to do so? How does the role of unofficial national standards, such as those produced by

professional organizations in the U.S.,[22] compare with the role of those produced by official government agencies in other countries? The TIMSS data offer an unparalleled opportunity to learn how curriculum is directed and organized in a wide variety of countries. Analyses of these data also will allow probing of the concept of "national curriculum," its essential elements, and factors that influence its nature and functions in different cultural and political contexts.

- ***What is the role of the teacher, and how do teachers learn to do what they do?***

  Looking at instructional practice across such a wide diversity of cultural contexts raises questions about teachers and the work of teaching. It will important to probe beneath the surface similarities and differences in teachers' roles in different contexts, to find out who teachers are, and to examine how they learn and develop their practice. What are the opportunities and conditions that contribute to what teachers do? In what ways do teachers' opportunities and conditions need to be considered when we look at instructional practices in other countries? How might these issues inform teacher preparation and professional development programs? Understanding of these issues is crucial in considering adaptation of practices across cultural settings.

- ***How do differences in educational practice among countries affect students?***

  On one hand, examining variations in intended and instructional practice is interesting. Much can be learned about the multiple forms that education can take across countries. On the other hand, the critical questions center on how these different approaches to curriculum and instruction affect educational outcomes, specifically student performance. For example, the six SMSO countries allocate substantially different amounts of time to particular topics, and their curricula reflect great variation in the number of topics intended for students to learn at each grade. These findings lead to questions about whether and how such practices may affect student achievement. How do students fare in systems that cover fewer topics per year? How does this curricular stance affect the thinking and practice of teachers? The TIMSS data not only have the potential to provide portraits of topic coverage across countries but also may afford an important opportunity to analyze the relations between the depth or breadth of the curriculum and what students learn.

What patterns or relationships can be unearthed in these vast data sets that offer insights into what affects what students learn? The SMSO report underscores the fact that what can be learned from TIMSS will depend on developing methods of analysis that maintain a serious respect for the complexity of ideas such as "curriculum," "instruction," and "culture" and that do not seek simplistic relationships among what are complicated elements and interconnections.

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[22] National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author, and National Research Council. (1996). *National science education standards*. Washington, DC: Author.

In addition to core questions of teaching, learning, and international comparisons, there are also crucial questions about the American educational system that the TIMSS data allow us to examine. In the following paragraphs, we illustrate two such questions.

- ***How coherent is the U.S. system?***

  The American system is sometimes criticized for its decentralization and fragmentation. The SMSO portrait seems to confirm that image, with goals being set at different levels of the system and neither teachers nor textbooks required to adhere to the goals. Is the American system as incoherent as the portrait seems to suggest? How much variation actually exists within the U.S. curriculum -- in goals, textbooks, and teaching? Do U.S. teachers feel less compelled to adhere to goals than teachers in other countries? Are teachers in other countries reporting or exercising more autonomy than expected? Are U.S. teachers more uniformly directed -- by textbooks or tests -- than is commonly assumed? Do nationally marketed tests and textbooks, as well as dominant cultural beliefs and images of teaching, have a homogenizing effect on practice? The TIMSS data may offer opportunities to scrutinize what local control means and how it is enacted in the U.S.

- ***Have the recent mathematics and science education reforms influenced curriculum and instructional practices in the U.S.?***

  With the publication of several documents in the last decade,[23] the U.S. has been focused on reforming mathematics and science education. Many will look to TIMSS for evidence about the extent to which the reform ideas have affected practice, in the hope of learning about the effects of reform on student achievement. To do this, it will be important to look closely at the different dates of different parts of TIMSS and to learn what data was gathered when relative to the significant dates in the reform activities. The National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* were released in 1989; the American Association for the Advancement of Science's *Benchmarks for Science Literacy* in 1993; and the National Research Council *National Science Education Standards* in 1996. The dates of the teacher questionnaire data from TIMSS precede the release of the *National Science Education Standards*, for example.

  Because instructional materials require several years for development and production, the TIMSS curriculum study includes materials produced well before the publication of mathematics and science content standards. Data reported on curriculum coverage, topic inclusion, and pacing do not reflect standards-influenced textbooks and curriculum materials that have come on to the

[23]National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author. National Research Council. (1996). *National science education standards.* Washington, DC: Author.; American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.; American Association for the Advancement of Science. (1989). *Science literacy.* New York: Oxford University Press.; and National Science Teachers Association. (1992). *Scope, sequence, and coordination of secondary school science.* Vol 1. Washington, DC: Author.

market in the last two or three years. It also will be important to consider other studies of the contemporary instructional reform in science and mathematics education[24] in order to determine whether what was occurring in the years of TIMSS-data gathering is consistent with the trends of standards-based reform. For example, studies conducted in the early 1990s suggest that the mathematics standards were only beginning to influence classrooms in a significant way.[25]

Conclusion

The release of the report on SMSO, to be followed closely by the release of several components of TIMSS, offer an important opportunity to learn more about international variations in curriculum and instructional practice in mathematics and science. Many attempts will probably be made to draw rapid conclusions from TIMSS regarding what should be done to "fix" American mathematics and science education. Issues that emerge from SMSO can guide the continuing analysis of TIMSS data, both by helping to shape the major questions asked of the data and by ensuring that the analysis will examine the complexity, variety, and subtlety of differences in educational goals, materials, and practice around the world. Although it will be difficult to avoid the comparison of achievement independent of context and culture, it is essential that we ask good questions and develop adequate explanations for variations within and between educational systems and that we study their connections to what students seem to learn.

The TIMSS data themselves will not "speak." To learn the kinds of things made possible by the availability of the TIMSS data will require raising critical questions and employing sophisticated methods for pursuing the answers. The secondary analyses possible from these data are significant; we now need discussions about the crucial issues to investigate and ways to do so. TIMSS data will provide a rare opportunity in discourse about mathematics and science education, its analysis, and improvement. We urge a stance of enlightened inquiry in that discourse.

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[24]Ferrini-Mundy, J. & Schram, T. (Eds.) (in press). The Recognizing and Recording Reform in Mathematics Education project: Insights, issues, and implications. *Journal for Research in Mathematics Education* (Monograph No. 8). Reston, VA: National Council of Teachers of Mathematics, and Prawat, R.S., Remillard J., Putnam, R. T., & Heaton, R.M. (1992). Teaching mathematics for understanding: Case studies of four fifth-grade teachers. *Elementary School Journal, (93).*

[25]Weiss, I. R., Matti, N. C., & Smith P. S. (1994). *Report of the 1993 national survey of science and mathematics education*. Chapel Hill, NC: Horizon Research, Inc.

APPENDIX 1:
Participating TIMSS Countries

Australia	France	Korea	Russian Federation
Austria	Germany	Kuwait	Scotland
Belgium (Flemish)	Greece	Latvia	Singapore
Belgium (French)	Hong Kong	Lithuania	Slovak Republic
Bulgaria	Hungary	Mexico	Slovenia
Canada	Iceland	The Netherlands	South Africa
Columbia	Indonesia	New Zealand	Spain
Cyprus	Iran	Norway	Sweden
Czech Republic	Ireland	Philippines	Switzerland
Denmark	Israel	Portugal	Thailand
England	Japan	Romania	United States of America

List provided by L. Suter, October 1996.

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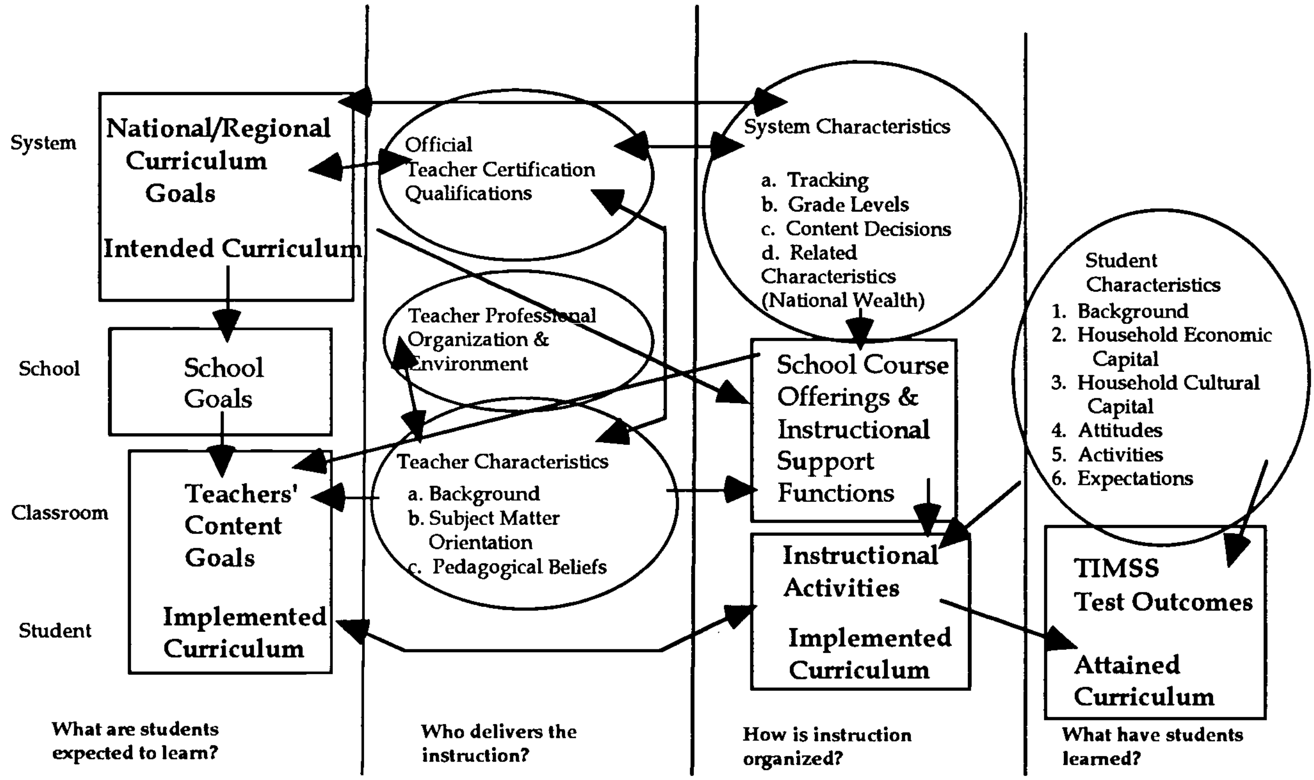
APPENDIX 2:
TIMSS Conceptual Model for the Provision of Educational Experiences



From *Characterizing pedagogical flow: An investigation of mathematics and science teaching in six countries* (p. 19) by W. Schmidt et al., in press, Dordrecht, The Netherlands: Kluwer Academic Publishers. Adapted with permission. Copyright © 1996 .

Recommended citation: National Research Council. (1996). *Mathematics and science education around the world: What can we learn from the Survey of Mathematics and Science Opportunities (SMSO) and the Third International Mathematics and Science Study (TIMSS)?* Washington, DC: National Academy Press.

Errata correction--missing from categories:

Content Aspects Mathematics
• Geometry: Symmetry
Content Aspects Science
• Life Sciences
Performance Expectations Aspects Mathematics
• Proportionality

APPENDIX 3:
Aspects and Categories in the TIMSS Mathematics and Science Analytic Frameworks

ASPECTS AND MAJOR CATEGORIES OF MATHEMATICS AND SCIENCE FRAMEWORKS	
Content Aspects	
Mathematics	*Science*
• Numbers • Measurement • Geometry: Position • Proportionality • Functions, relations, equations • Data probability, statistics • Elementary analysis • Validation and structure • Other content	• Earth sciences • Physical sciences • Science, technology, and mathematics • History of science and technology • Environmental issues • Nature of science • Science and other disciplines
Performance Expectations Aspects	
Mathematics	*Science*
• Knowing • Using routine procedures • Investigating and problem solving • Mathematical reasoning • Communicating	• Understanding • Theorizing, analyzing, solving problems • Using tools, routine procedures • Investigating the natural world • Communicating
Perspective Aspects	
Mathematics	*Science*
• Attitudes • Careers • Participation • Increasing interest • Habits of mind	• Attitudes • Careers • Participation • Increasing interest • Safety • Habits of mind

From *Curriculum Frameworks for Mathematics and Science* (p. 46), by D.F. Robitaille et al., 1993, TIMSS Monograph No. 1. Vancouver: Pacific Educational Press. Copyright © 1993 TIMSS. Adapted with permission.

See Appendix 4 for data release plans.

APPENDIX 4:
TIMSS Reporting Plans

October 1996

Characterizing Pedagogical Flow (SMSO report)
Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Mathematics
Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Science
A Splintered Vision: An Investigation of U.S. Science and Mathematics Education

November 1996

Eighth-Grade Mathematics and Science Performance in International Perspective
Findings from the U.S. Assessments and Questionnaires
Technical Report on the U.S. Findings and Questionnaires
TIMSS Classroom Videotape Studies: Preliminary Findings and Methodology
Findings from Ethnographic Case Studies in Germany, Japan, and the U.S.
Databases (U.S. assessments and questionnaires, mathematics classroom instruction videotapes, case study interview and field notes)

Summer 1997

Fourth-Grade Achievement and Questionnaire Results

Winter 1998

Twelfth-Grade Achievement and Questionnaire Results

Additional reports, papers, and analyses will continue for several years.

For additional information about TIMSS, contact:

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http://www.ed.gov/nces/timss.html

A brochure summarizing this report entitled Mathematics and Science Education Around the World: What Can We Learn? is also available. For copies of this publication, write:

Mathematical Sciences Education Board or Committee on Science Education K-12
Center for Science, Mathematics, and Engineering Education
National Research Council
2101 Constitution Ave., NW (HA 450), Washington, DC 20418
timss@nas.edu

Recommended citation: National Research Council. (1996). *Mathematics and science education around the world: What can we learn from the Survey of Mathematics and Science Opportunities (SMSO) and the Third International Mathematics and Science Study (TIMSS)?* Washington, DC: National Academy Press.

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